PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
MAGNA380PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US 99/ 29990	17/12/1999	21/12/1998
Applicant		
MAGNA INTERNATIONAL OF AMERICA, INC. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of Invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. _____

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 99/29990

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29C67/00 C08K3/34 B29C44/00

#2
07/31/2001

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C C08K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 739 007 A (OKADA AKANE ET AL) 19 April 1988 (1988-04-19) column 2, line 50 -column 3, line 65	1,2
Y	US 5 717 000 A (SUH KYUNG W ET AL) 10 February 1998 (1998-02-10) abstract column 1, line 1 -column 4, line 26	1,2
P,X	WO 99 61287 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2
P,X	WO 99 61281 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 May 2000	15/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Philpott, G

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 99/29990

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 99 61237 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2
P,X	WO 99 61236 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2
A	EP 0 747 323 A (AMCOL INTERNATIONAL) 11 December 1996 (1996-12-11) the whole document	1,2
A	US 5 001 005 A (BLANPIED ROBERT H) 19 March 1991 (1991-03-19) column 2, line 50 -column 3, line 30	1
A	US 5 747 560 A (MAXFIELD MACRAE ET AL) 5 May 1998 (1998-05-05) the whole document	1,2

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter ...nal Application No
PCT/US 99/29990

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4739007 A	19-04-1988	JP 62252425 A	04-11-1987
		JP 8022946 B	06-03-1996
		JP 62074957 A	06-04-1987
		DE 3632865 A	02-04-1987
US 5717000 A	10-02-1998	AU 712100 B	28-10-1999
		AU 2132297 A	10-09-1997
		BR 9707867 A	27-07-1999
		CA 2247194 A	28-08-1997
		CN 1212001 A	24-03-1999
		CZ 9802639 A	13-01-1999
		EP 0882089 A	09-12-1998
		NO 983856 A	21-08-1998
		PL 328459 A	01-02-1999
		WO 9731053 A	28-08-1997
WO 9961287 A	02-12-1999	NONE	
WO 9961281 A	02-12-1999	AU 4007499 A	13-12-1999
WO 9961237 A	02-12-1999	AU 4005799 A	13-12-1999
WO 9961236 A	02-12-1999	AU 4089099 A	13-12-1999
EP 0747323 A	11-12-1996	US 5578672 A	26-11-1996
		CA 2178398 A	08-12-1996
		JP 9020514 A	21-01-1997
		US 5721306 A	24-02-1998
		US 5837763 A	17-11-1998
		US 5760121 A	02-06-1998
		US 5844032 A	01-12-1998
		US 5849830 A	15-12-1998
		US 5877248 A	02-03-1999
US 5001005 A	19-03-1991	US 5112678 A	12-05-1992
		US 5102728 A	07-04-1992
US 5747560 A	05-05-1998	AT 159270 T	15-11-1997
		CA 2115255 A	04-03-1993
		DE 69222773 D	20-11-1997
		DE 69222773 T	12-02-1998
		EP 0598836 A	01-06-1994
		JP 2674720 B	12-11-1997
		JP 6504810 T	02-06-1994
		WO 9304117 A	04-03-1993
		WO 9304118 A	04-03-1993

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 24 August 2000 (24.08.00)	
International application No. PCT/US99/29990	**Applicant's or agent's file reference** MAGNA380PCT
International filing date (day/month/year) 17 December 1999 (17.12.99)	**Priority date** (day/month/year) 21 December 1998 (21.12.98)
Applicant WILSON, Phillip, S.	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

12 July 2000 (12.07.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Henrik Nyberg
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* MAGNA380PCT

Box No. I TITLE OF INVENTION

STRUCTURAL FOAM COMPOSITE HAVING NANO-PARTICLE REINFORCEMENT AND METHOD OF MAKING THE SAME

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MAGNA INTERNATIONAL OF AMERICA, INC.
600 Wilshire Drive
Troy Michigan 48084
United States of America

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

WILSON, Phillip S.
5480 Huron Hills Drive
Commerce Township, Michigan 48382
United States of America

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

BARUFKA, Jack S.
PILLSBURY MADISON & SUTRO LLP
1100 New York Avenue, N.W.
Washington, D.C. 20005
United States of America

Telephone No. 202 861 3000

Facsimile No. 202 822 0944

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked):*

Regional Patent

☒ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SL Sierra Leone, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Cote d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line):*

☒ **AE** United Arab Emirates
☒ **AL** Albania .....
☒ **AM** Armenia .....
☒ **AT** Austria .....
☒ **AU** Australia .....
☒ **AZ** Azerbaijan
☒ **BA** Bosnia and Herzegovina .....
☒ **BB** Barbados
☒ **BG** Bulgaria .....
☒ **BR** Brazil .....
☒ **BY** Belarus .....
☒ **CA** Canada
☒ **CH and LI** Switzerland and Liechtenstein
☒ **CN** China .....
☒ **CU** Cuba .....
☒ **CZ** Czech Republic .....
☒ **DE** Germany .....
☒ **DK** Denmark .....
☒ **EE** Estonia .....
☒ **ES** Spain .....
☒ **FI** Finland .....
☒ **GB** United Kingdom
☒ **GD** Grenada
☒ **GE** Georgia .....
☒ **GH** Ghana .....
☒ **GM** Gambia
☒ **HR** Croatia .....
☒ **HU** Hungary .....
☒ **ID** Indonesia
☒ **IL** Israel .....
☒ **IN** India .....
☒ **IS** Iceland
☒ **JP** Japan .....
☒ **KE** Kenya .....
☒ **KG** Kyrgyzstan .....
☒ **KP** Democratic People's Republic of Korea .....
☒ **KR** Republic of Korea .....
☒ **KZ** Kazakhstan .....
☒ **LC** Saint Lucia
☒ **LK** Sri Lanka
☒ **LR** Liberia
☒ **LS** Lesotho .....
☒ **LT** Lithuania
☒ **LU** Luxembourg
☒ **LV** Latvia
☒ **MD** Republic of Moldova .....
☒ **MG** Madagascar .....
☒ **MK** The former Yugoslav Republic of Macedonia .....
☒ **MN** Mongolia
☒ **MW** Malawi .....
☒ **MX** Mexico .....
☒ **NO** Norway
☒ **NZ** New Zealand .....
☒ **PL** Poland .....
☒ **PT** Portugal .....
☒ **RO** Romania
☒ **RU** Russian Federation .....
☒ **SD** Sudan
☒ **SE** Sweden
☒ **SG** Singapore
☒ **SI** Slovenia .....
☒ **SK** Slovakia .....
☒ **SL** Sierra Leone
☒ **TJ** Tajikistan .....
☒ **TM** Turkmenistan .....
☒ **TR** Turkey .....
☒ **TT** Trinidad and Tobago .....
☒ **UA** Ukraine .....
☒ **UG** Uganda .....
☒ **US** United States of America .....
continuation .....
☒ **UZ** Uzbekistan .....
☒ **VN** Viet Nam .....
☒ **YU** Yugoslavia .....
☒ **ZA** South Africa .....
☒ **ZW** Zimbabwe .....

Check-boxes reserved for designating States which have become party to the PCT after issuance of this sheet:

☒ **CR** Costa Rica ☒ **TZ** United Republic of Tanzania
☒ **DM** Dominica ☒ **-MA** Morocco

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Supplemental Box *If the Supplemental Box is not used, this sheet need not be included in the request.*

*1. If, in any of the Boxes, **the space is insufficient** to furnish all the information: in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*

*(i) **if more than two persons are involved as applicants and/or inventors** and no "continuation sheet" is available: in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below;*

*(ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication **"the States indicated in the Supplemental Box"** is checked: in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant;*

*(iii) if, in Box No. II or in any of the sub-boxes of Box No. III, **the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America:** in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor;*

*(iv) if, in addition to the agent(s) indicated in Box IV, there are **further agents**: in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*

*(v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication **"patent of addition,"** or **"certificate of addition,"** or if, in Box No. V., the name of the United States of America is accompanied by an indication **"continuation"** or **"continuation-in-part"**: in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI) , the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*

*(vi) if, in Box No. VI, there are **more than three earlier applications whose priority is claimed:** in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI;*

*(vii) if, in Box No. VI, the **earlier application is an ARIPO application:** in such case, write "Continuation of Box No. VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.*

*2. If, with regard to the **precautionary designation statement** contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement: in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each State so excluded.*

*3. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning **non-prejudicial disclosures or exceptions to lack of novelty**: in such case, write "Statement concerning non-prejudical disclosures or exceptions to lack of novelty" and furnish that statement below.*

Box No. iV. Agent or Common Representative: (continued)

KOKULIS, Paul N.	BIRD, Donald J.	EDGELL, G. Paul
LIPPITT, Raymond F.	ECCLESTON, Lynn E.	JAKOPIN, David A.
KNIGHT, G. Lloyd	GOWDEY Peter W.	PAULSON, Mark G.
LOVE, Carl G.	LAZAR, Dale S.	KLIMA, Timothy J.
MARTIN, Edgar H.	PERRY, Glenn J.	McQUADE, Paul F.
CQLTON, Kendrew H.	MORDUCH, Ruth N.	DZWONCZYK, Michael R
JOYCE, Kevin E.	WHITE, Paul E., Jr.	SIRILLA, George M.
WISE, Roger R.	BENGTSSON, W. Patrick	
ZAITLEN, Richard H.	SMYRSKI, Steven W	KIRKPATRICK, Anita M.
HESS, Adam R.	GLAZIER, Stephen C.	
FINKELSTEIN, Jay M.	NAGY, Paul G.	

All attorneys are partners of the firm of PILLSBURY MADISON & SUTRO, LLP. The address, telephone number, and facsimile number of all the above attorneys are as indicated in Box IV.

Box No. V Designation of States (continued)

US: 60/113,126037 filed 21 December 1998 (21.12.98)

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 21 December 1998 (21.12.98)	60/113,134	US		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA/ EP

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* Number Country (or regional Office)

Box No. VIII CHECK LIST: LANGUAGE OF FILING

This international application contains the following **number of sheets:**

request	:	4
description (excluding) sequence listing part)	:	12
claims	:	1
abstract	:	1
drawings	:	0
sequence listing part of description	:	
Total number of sheets	:	18

This international application is **accompanied** by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as items(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify):* Transmittal Fee to US/RO and return post card

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: ENGLISH

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

Jack S. Barufka

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA/
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's file reference: **MAGNA380PCT**

Applicant: **MAGNA INTERNATIONAL OF AMERICA, INC.**

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE . . . . . **240.00** T

2. SEARCH FEE . . . . . **1,002.00** S

International search to be carried out by **EP**

(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

The international application contains **18** sheets.

first 30 sheets . . . . . **455.00** b_1

0 remaining sheets x _____ additional amount = **0.00** b_2

Add amounts entered at b_1 and b_2 and enter total at B . . **455.00** B

Designation Fees

The international application contains **all** designations.

10 number of designation fees payable *(maximum 10)* x **105.00** amount of designation fee = **1,050.00** D

Add amounts entered at B and D and enter total at I . . . . . **1,505.00** I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and

4. FEE FOR PRIORITY DOCUMENT *(if applicable)* . . . . . **15.00** P

5. TOTAL FEES PAYABLE

Add amounts entered at T, S, I and P, and enter total in the TOTAL box: **2,762.00** TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

- ☒ authorization to charge deposit account (see below)
- ☐ bank draft
- ☐ coupons
- ☒ cheque
- ☐ cash
- ☐ other *(specify):*
- ☐ postal money order
- ☐ revenue stamps

DEPOSIT ACCOUNT AUTHORIZATION *(this mode of payment may not be available at all receiving Offices)*

The RO/ **US**

☐ is hereby authorized to charge the total fees indicated above to my deposit account.

☒ *(this check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit)* is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.

☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account.

03-3975 Deposit Account Number

17 December 1999 Date *(day/month/year)*

Signature

See Notes to the fee calculation sheet

15

PATENT COOPERATION TREATY

REC'D 26 JAN 2001
WIPO PCT

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
MAGNA380PCT		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US99/29990	17/12/1999	21/12/1998
International Patent Classification (IPC) or national classification and IPC B29C67/00		
Applicant MAGNA INTERNATIONAL OF AMERICA, INC. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☒ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/07/2000	24.01.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Philpott, G Telephone No. +49 89 2399 8620

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US99/29990

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

2-12	as originally filed				
1	as received on	11/01/2001	with letter of	08/01/2001	

Claims, No.:

1,2	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   ☐ the language of publication of the international application (under Rule 48.3(b)).
   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.
   ☐ filed together with the international application in computer readable form.
   ☐ furnished subsequently to this Authority in written form.
   ☐ furnished subsequently to this Authority in computer readable form.
   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☐ the claims, Nos.:
   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1,2
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1,2
Industrial applicability (IA)	Yes:	Claims	1,2
	No:	Claims	

2. Citations and explanations
   see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

1.1 US-A-4 739 007 (D1) teaches the use of reinforcing silicate layers in thermoplastics, each layer being 0.7-1.2 nm thick, which is precisely the same range as given in the present application. D1 also teaches a silicate layer parts by 100 parts weight range of 0.5 - 150, which thus includes the 2%-15% volume range specified in present claim 1. D1 implies that the number of layers in each particle is low, but makes no explicit disclosure of any particular number of layers. However, it is apparent from the available literature that the exclusive use of particles less than 20 layers thick are standard practice in the art. For example, US-A-5 747 560 (D2) advises the skilled man on the incorporation into a plastic composite of platelet-based particles as a reinforcing agent, and explicitly states that the platelets comprise less than 10 layers. Moreover, EP-A-0 747 323 (D3) teaches particles of 4-5 layers (e.g. p. 4, l. 57). Thus it can be seen that claim 1 is merely addressing the **use** of a known reinforcing technique for thermoplastic foams. The use of nanoparticle reinforcement into foams comprising a blowing agent is however also known. As an example US-A-5 717 000 (D4) is cited.

1.2 Claim 1 is therefore nothing more than a juxtaposition of known features and uses, all of which are at the disposal of the skilled man, and which he has every motivation to combine in the way claimed. Moreover, the claimed combination does not overcome any single specific problem in an inventive manner, nor does it produce a surprising result.

1.3 Claim 1, and by logical extension claim 2, thus fails to meet the requirements of Art. 33(3) PCT.

2. With respect to Rule 70.10 PCT, attention is drawn to WO9961236, WO9961237 and WO9961287, all published on 021299 and all filed on 200599 and all with a US priority date of 220598.

3. D1-D4 are not incorporated into the description ((Rule 5.1(a)(ii) PCT).

4. The two-part claim style is not used (Rule 6.3 PCT).

5. The last paragraph on page 12 renders the scope of the application ambiguous, and should be deleted (PCT Preliminary Examination Guidelines-III-4.3a).

STRUCTURAL FOAM COMPOSITE HAVING NANO-PARTICLE REINFORCEMENT AND METHOD OF MAKING THE SAME

This patent application claims priority from U.S. Provisional Application No. 60/113,134 filed December 21, 1998.

BACKGROUND OF THE INVENTION

Foamed plastics are plastics having reduced apparent densities due to the presence of numerous cells disposed throughout the mass of the polymer. Rigid foams usually produced at greater than about 320 kg/m^3 density are known as structural foams, and are well known in the art. Structural foams are commonly used in various aspects of manufacturing molded articles in which low density polymer materials are desirable. Cellular polymers and plastics are made by a variety of methods having the basic steps of cell initiation, cell growth and cell stabilization. Structural foams having an integral skin cellular core and a high strength to weight ratio are made by several processes, including injection molding and extrusion molding, wherein a particular process is selected based upon product requirements.

Injection molding of structural foams is usually conducted under either low pressure or high pressure conditions. For example, during the injection molding process, a chemical blowing agent is typically introduced to the polymer resin melt in the extrusion barrel of an injection molding machine. The temperature of the extrusion barrel is increased under pressure, after which the pressure is released, injecting the polymer into a mold, permitting the chemical blowing agent to generate gas within the polymer. The expansion of the blowing agent pushes molten polymer material against the walls of the mold such that the material in contact with the walls has a higher density than the material toward the middle of the molded article. This establishes a density gradient wherein the outer surface areas of an injection molded article have a greater density than the core of the part due to more foaming in the

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : B29C 67/00, C08K 3/34, B29C 44/00 — A1

(11) International Publication Number: **WO 00/37242**

(43) International Publication Date: 29 June 2000 (29.06.00)

(21) International Application Number: PCT/US99/29990

(22) International Filing Date: 17 December 1999 (17.12.99)

(30) Priority Data:
60/113,134 21 December 1998 (21.12.98) US

(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application
US 60/113,134 (CON)
Filed on 21 December 1998 (21.12.98)

(71) Applicant *(for all designated States except US)*: MAGNA INTERNATIONAL OF AMERICA, INC. [US/US]; 600 Wilshire Drive, Troy, MI 48084 (US).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: WILSON, Phillip, S. [US/US]; 5480 Huron Hills Drive, Commerce Township, MI 48382 (US).

(74) Agents: BARUFKA, Jack, S. et al.; Pillsbury Madison & Sutro LLP, 1100 New York Avenue, N.W., Washington, DC 20005 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: STRUCTURAL FOAM COMPOSITE HAVING NANO–PARTICLE REINFORCEMENT AND METHOD OF MAKING THE SAME

(57) Abstract

A structural foam article suitable for molding into automobile trim, the article comprising at least one thermoplastic; about 2 % to about 15 % by volume reinforcing particles having one or more layers of 0.7nm–1.2 nm thick platelets, wherein more than about 50 % of the reinforcing particles are less than about 20 layers thick; at least one blowing agent present in a range from about 0.5 % to about 10 % by weight. A method of producing structural foam articles comprising this structural foam is also disclosed.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

STRUCTURAL FOAM COMPOSITE HAVING NANO-PARTICLE REINFORCEMENT AND METHOD OF MAKING THE SAME

BACKGROUND OF THE INVENTION

Foamed plastics are plastics having reduced apparent densities due to the presence of numerous cells disposed throughout the mass of the polymer. Rigid foams usually produced at greater than about 320 kg/m^3 density are known as structural foams, and are well known in the art. Structural foams are commonly used in various aspects of manufacturing molded articles in which low density polymer materials are desirable. Cellular polymers and plastics are made by a variety of methods having the basic steps of cell initiation, cell growth and cell stabilization. Structural foams having an integral skin cellular core and a high strength to weight ratio are made by several processes, including injection molding and extrusion molding, wherein a particular process is selected based upon product requirements.

Injection molding of structural foams is usually conducted under either low pressure or high pressure conditions. For example, during the injection molding process, a chemical blowing agent is typically introduced to the polymer resin melt in the extrusion barrel of an injection molding machine. The temperature of the extrusion barrel is increased under pressure, after which the pressure is released, injecting the polymer into a mold, permitting the chemical blowing agent to generate gas within the polymer. The expansion of the blowing agent pushes molten polymer material against the walls of the mold such that the material in contact with the walls has a higher density than the material toward the middle of the molded article. This establishes a density gradient wherein the outer surface areas of an injection molded article have a greater density than the core of the part due to more foaming in the

center of the article. Thus, a gradient is established having smaller cells present near the mold surface with increasingly larger cells present toward the center of the article.

The use of blowing agents permits short shooting during the molding process. That is, because the blowing agent increases the volume of the expanding polymer composition, the mold is filled with less resin material than would be required without a blowing agent. Consequently, the density of the molded article may be reduced by about 10% to about 20% over articles molded without an incorporated blowing agent. Use of less polymer resin has the advantage of decreasing the weight of the final molded product.

Initiation of cell formation and promotion of cells of a given size are controlled by nucleation agents included in the polymer composition. The nature of cell-control agents added to the polymer compositions influence the mechanical stability of the foamed structure by changing the physical properties of the plastic phase and by creating discontinuities in the plastic phase which allows the blowing agent to diffuse from the cells to the surrounding material. Typically, the resulting cells provide for a lightweight molded article, but do so at the expense of impact resistance. For example, nucleation agents often promote crystalline structures within the cooled polymer, which reduce impact resistance. Mineral fillers may be added to provide a large number of nucleation sites, but such fillers tend to serve as stress concentrators, promoting crack formation and decreasing the impact resistance of molded articles.

Poor impact resistance of structural foam articles may be improved by the inclusion of glass fibers in the polymer melt during processing. However, glass fibers are generally too large to substantially reinforce the foam cells formed by the bubble structures. Glass fibers are often coated with sizing agents, which may induce

clumping and impair even dispersion of the fibers. In addition, the amount of glass fibers required to achieve reasonable impact resistance of structural foam increases the specific gravity of polymer used therein, thereby increasing the density of the foamed article. This defeats the purpose of using lightweight foamed articles in the manufacture of, for example, automobiles, where lightweight components are highly desirable. Consequently, the levels of glass fibers in polymer compositions for foamed articles are kept relatively low, meaning impact resistance of the molded products is poor.

Typically, the reduced strength of structural foams may be at least partially offset by increasing the wall thickness of molded articles. Increasing wall thickness requires more raw materials per unit molded, thereby increasing the cost of production.

U.S. Patent number 5,753,717 to Sanyasi discloses a method of producing foamed plastics with enhanced physical strength. The structural foams of Sanyasi utilize CO_2 in combination with an adjustment in the extrusion temperature of molten polystyrene resins to improve foam strength. This process, however, does not improve the foam strength of other types of resins, and is not suitable for enhancing the strength of articles for use in, for example, automotive trim.

Structural foam automotive parts historically have inconsistent surface appearances due to variations in the density of the polymer near the skin or surface of these molded articles. The imperfections in the surfaces of molded structural foam articles usually limits the usage of these foam products to non-appearance (e.g., hidden or non-visible) parts or parts in which the surface has been textured. Examples of these structural automotive interior trim products include interior door panel structural members, instrument panel retainers, interior seat backs covered with fabric,

load floors in the storage compartments of vehicles, side wall trim and the like. Some pickup truck beds can be made from structural foam. All of these products require reduced density and good impact resistance.

SUMMARY OF THE INVENTION

An object of the present invention is to overcome the problems delineated hereinabove. In accordance with this object, the present invention provides a structural foam article suitable for use as automobile trim. The article (and hence the composition forming the article) comprises at least one thermoplastic; about 2% to about 15% by volume reinforcing particles having one or more layers of 0.7nm-1.2 nm thick platelets, wherein more than about 50% of the reinforcing particles are less than about 20 layers thick, and wherein more than about 99% of the reinforcing particles are less than about 30 layers thick; and there is at least one blowing agent present in a range from about 0.5% to about 10% by weight. The automotive trim component is constructed and arranged to be both lightweight and strong, exhibiting good impact resistance.

It is a further object of the present invention to provide a method which overcomes the problems delineated above. Accordingly, there is provided a method of producing structural foam articles which comprises preparing a melt of at least one thermoplastic having about 2% to about 15% by volume reinforcing particles. The reinforcing particles have one or more layers of 0.7nm-1.2nm thick platelets, wherein more than about 50% of the reinforcing particles are less than about 20 layers thick. More than about 99% of the reinforcing particles are less than about 30 layers thick. The melt comprises at least one blowing agent present in a range from about 0.5% to about 10% by weight. The polymer melt is subjected to a molding process, wherein

the molding process is a process selected from the group consisting of injection molding and extrusion molding.

This and other objects of the invention can be more fully appreciated from the following detailed description of the preferred embodiments.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the present invention, reinforcing nanoparticle fillers are added in levels of only a few percent by volume to polymer compositions prior to molding into the article. As a result, the impact resistance of molded articles made of, for example, polyolefins, is improved. For example, automobile splash guards and fender liners may utilize greater amounts of recycled polypropylene when combined with reinforcing nanoparticles to create strong molded parts, thereby requiring less higher cost virgin polymers and using as much as 30% less material overall due to improved strength. Use of lower cost, reinforced materials for the interior trim of an automobile is an effective way to provide impact resistant components without negatively affecting the production cost per automobile.

The automotive parts manufactured in accordance with the present invention comprise a composite material of a polymer having dispersed therein reinforcement fillers in the form of very small mineral reinforcement particles. The reinforcement filler particles, also referred to as "nanoparticles" due to the magnitude of their dimensions, each comprise one or more essentially flat platelets. Generally, each platelet has a thickness of between about 0.7-1.2 nanometers. The average platelet thickness is approximately 1 nanometer.

The preferred aspect ratio, which is the largest dimension divided by the thickness of each particle, is about 50 to about 300. At least 80% of the particles

should be within this range. If too many particles have an aspect ratio above 300, the material becomes too viscous for forming parts in an effective and efficient manner. If too many particles have an aspect ratio of smaller than 50, the particle reinforcements will not provide the desired reinforcement characteristics. More preferably, the aspect ratio for each particle is between 100-200. Most preferably at least 90% of the particles have an aspect ratio within the 100-200 range.

The platelet particles or nanoparticles are derivable from larger layered mineral particles. Any layered mineral capable of being intercalated may be employed in the present invention. Layered silicate minerals are preferred. The layered silicate minerals that may be employed include natural and artificial minerals. Non-limiting examples of more preferred minerals include montmorillonite, vermiculite, hectorite, saponite, hydrotalcites, kanemite, sodium octosilicate, magadite, and kenyaite. Mixed Mg and Al hydroxides may also be used. Various other clays can be used, such as claytone H.Y. Among the most preferred minerals is montmorillonite.

To exfoliate the larger mineral particles into their constituent layers, different methods may be employed. For example, swellable layered minerals, such as montmorillonite and saponite are known to intercalate water to expand the inter layer distance of the layered mineral, thereby facilitating exfoliation and dispersion of the layers uniformly in water. Dispersion of layers in water is aided by mixing with high shear. The mineral particles may also be exfoliated by a shearing process in which the mineral particles are impregnated with water, then frozen, and then dried. The freeze dried particles are then mixed into molten polymeric material and subjected to a high sheer mixing operation so as to peel individual platelets from multi-platelet particles and thereby reduce the particle sizes to the desired range.

The polymer composites of the present invention are prepared by combining the platelet mineral with the desired polymer in the desired ratios. The components can be blended by general techniques known to those skilled in the art. For example, the components can be blended and then melted in mixers or extruders.

Additional specific preferred methods, for the purposes of the present invention, for forming a polymer composite having dispersed therein exfoliated layered particles are disclosed in U.S. Patent Nos. 5,717,000, 5,747,560, 5,698,624, and WO 93/11190, each of which is hereby incorporated by reference. For additional background, the following are also incorporated by reference: U.S. Patent Nos. 4,739,007 and 5,652,284.

Generally, expandable plastic formulations include polystyrenes, poly(vinyl chlorides), polyethylene, polyurethanes, polyphenols and polyisocyanates. A preferred thermoplastic is used, and based on the selection of thermoplastic determines the temperature at which foaming commences, the type of blowing agent used and the cooling conditions required for dimensional stabilization of the foam. Preferably, the thermoplastic used in the present invention is a polyolefin or a homogenous or copolymer blend of polyolefins. The preferred polyolefin is at least one member selected from the group consisting of polypropylene, ethylene-propylene copolymers, thermoplastic olefins (TPOs), and thermoplastic polyolefin elastomers (TPEs). For high performance applications, engineering thermoplastics are most preferred type of thermoplastic. Such engineering thermoplastic resins may include polycarbonate (PC), acrylonitrile butadiene styrene (ABS), a PC/ABS blend, polyethylene terephthalates (PET), polybutylene terephthalates (PBT), polyphenylene oxide (PPO), or the like.

The exfoliation of layered mineral particles into constituent layers need not be complete in order to achieve the objects of the present invention. The present invention contemplates that at least 99% of the particles should be less than about 30 nanometers (30 layers or platelets) in thickness, and that more than about 50% of the particles should be less than about 20 nanometers (20 layers or platelets) in the thickness direction. Preferably, at least 90 % of the particles should have a thickness of less than 5 layers. Also, it is preferable for at least 70% of the particles should have a thickness of less than 5 nanometers. It is most preferable to have as many particles as possible to be as small as possible, ideally including only a single platelet. Particles having more than 30 layers behave as stress concentrators and should be avoided, to the extent possible.

Generally, in accordance with the present invention, each of the automotive parts that can be manufactured in accordance with the principles of the present invention should contain nanoparticle reinforcement in amounts less than 15% by volume of the total volume of the part. The balance of the part is to comprise an appropriate thermoplastic material, a blowing agent and optionally, suitable additives. If greater than 15% by volume of reinforcement filler is used, the viscosity of the composition becomes too high and thus difficult to mold. Preferably, the amount of reinforcing nanoparticles is greater than 2% by volume (as lower amounts would not achieve the desired increase in strength) and less than 15%. More preferably, the nanoparticles comprise less than 13% and greater than 3% of the total volume of the part for extrusion molding.

Preferably, relatively rigid injection molded trim parts comprise reinforcement particles of the type described herein at about 2-10% of the total volume of the part, with the balance comprising the thermoplastic substrate. It is even more preferable for

these interior panels to have reinforcement particles of the type contemplated herein comprising about 3%-8% of the total volume of the part. For some applications, inclusion of about 3%-5% reinforcing nanoparticles is optimal. Inclusion of more than 10% nanoparticles tends to increase the viscosity of the composition to point which impairs injection molding.

Blowing agents incorporated into the compositions according to the invention govern the amount of gas generated during polymer processing and molding, and thus control the density of the final product. The type of agent used determines the rate of gas production, the pressure developed during gas expansion, and the relative amount of gas lost from the system to the amount of gas retained within the cells. Blowing agents may be either physical or chemical agents; chemical agents are preferred. Chemical agents may be organic or inorganic compounds. Commonly used inorganic blowing agents include CO_2, nitrogen, helium, argon and air. Organic agents include volatile organics and halogenated hydrocarbons, such as chlorofluorocarbons, and hydrochlorofluorocarbons, although their use is diminishing due to environmental concerns. Volatile organic compounds include aliphatic hydrocarbons, such as propane, n-butane, neopentane, hexane, and the like. Preferred blowing agents are azo compounds which produce CO_2 and O_2 in the presence of heat. Preferably, at least one blowing agent is present in the polymer composition (and hence the molded article) in a range from about 0.5 % to about 10%, more preferably about 0.5% to about 4 % by weight. Combinations of more than one blowing agent may be used.

Additives or cell control agents heavily influence the nucleation of foam cells by altering surface tension of the polymer system or by serving as nucleation sites from which cells can grow. Nucleation agents are often added to polymer compositions to promoting bubble formation during processing of polypropylenes.

Nucleation agents can be selected to develop cells of a particular pore size. Suitable nucleating agents include metal aromatic carboxylates, sorbitol derivatives, inorganic compounds and organic phosphates. Examples are aluminum hydroxyl di-p-t-butyl benzoate, dibenzylidene sorbitol, magnesium silicate (talc), sodium 2,2'-methylene bis (4,6-di-t-butylpheyl) phosphate and zinc oxide. Inorganic nucleation agents are often chemically modified to improve dispersion throughout the polymer composition. The chosen nucleation agent will influence the mechanical properties of the polymer composition, and should be selected accordingly. For example, some fillers induce crystallization of polymers, which impairs impact resistance of molded articles.

The nanoparticles of the invention also advantageously behave as nucleating agents in polymer compositions. The extremely small size of these reinforcing particles permits them to be evenly dispersed throughout the polymer composition. Accordingly, the extremely small size and even distribution of the nanoparticles provides for between about 20 to about 100 times more potential nucleation sites within the polymer composition than can be achieved in an equivalent volume using larger, standard nucleation agents.

Specifically, for each 1% loading of nanoparticles by volume, there exists a minimum of at least about 10^{11} particles, and hence potential nucleation sights (one for each particle), per cubic centimeter of structural foam, where more than 50% of the reinforcement particles are less than about 20 platelets thick, and wherein the majority of reinforcement particles have a total particle size of less than about 20nm x 200nm x 300 nm. Where the majority (>50%) of particles are one platelet thick and have an approximate total particle size of about 1.2nm x 50nm x 75nm or less, the potential nucleation sites increases to at least about 10^{14} per 1% loading of reinforcement particles. Where the majority (>50%) particles are one platelet thick and have an

approximate total particle size of about 1.2nm x 200nm x 300nm or less, the potential nucleation sites is about 2 x 10^{12} per 1% loading of reinforcement particles. In the broad aspect of the invention, it is contemplated that there exists at least 10^{11} particles for each 1% loading of nanoparticles per cubic centimeter of structural foam, with the balance of the cubic centimeter being formed from the other constituent components of structural foam, such as thermoplastic material, blowing agent, and optionally, at least one additive.

When about 90% of the nanoparticles in the composition are less than 5 nm in thickness, a more preferred uniform distribution of the particles occurs in the resin, which translates into evenly distributed gas bubble formation during blow molding. A reduction to near elimination of clusters of nucleation agent can be achieved, accordingly. The advantage to nanoparticle nucleation is the near elimination of nucleation stress concentrators in concert with substantial reinforcement of foam cells, which is not possible with existing nucleation agents.

In addition to nucleating agents, other additives may optionally be included in the polymer composition to improve processability. For example, aging modifiers, such as glycerol monostearate, are useful additives in polymer compositions for molding. Aging modifiers are typically present in an amount from about 0.5% to about 5% polyolefin resin. Lubricants may also be present to enhance extrusion of the polymer composition during molding. Other additives include pigments, heat stabilizers, antioxidants, flame retardants, ultraviolet absorbing agents and the like.

Reinforced articles of the invention exhibit improved properties over non-reinforced articles. For example, polyethylene articles having 5% nanoparticles by volume, wherein 90% of the particles have 5 or fewer layers, increased flexural modulus by 2.5 to about 3 times over compositions lacking reinforcing nanoparticles,

as measured under ASTM D790 test conditions. This 5% nanoparticle polyethylene composition exhibited > 200% elongation to rupture. By contrast, about 25% glass fiber reinforcement is required in such articles to achieve an equivalent modulus. Polypropylene articles according to the invention showed about a 60% improvement in flexural modulus over articles lacking reinforcement nanoparticles. Thus, the use of reinforcing nanoparticles according to the invention provides articles having good flexural stiffness.

The specific gravity of structural foams having reinforcing nanoparticles is typically 22.5% lower than in materials lacking a blowing agent, which is 50% less dense than the blow molded foams known in the art.

It should be appreciated that the foregoing description is illustrative in nature and that the present invention includes modifications, changes, and equivalents thereof, without departure from the scope of the invention.

What is claimed is:

1. A structural foam article comprising:

(a) at least one thermoplastic;

(b) about 2% to about 15% by volume reinforcing particles, each of said reinforcing particles having one or more layers of 0.7nm-1.2 nm thick platelets, wherein more than about 50% of the reinforcing particles are less than about 20 layers thick, and wherein more than about 99% of the reinforcing particles are less than about 30 layers thick; and

(c) at least one blowing agent present in a range from about 0.5% to about 10% by weight.

2. A method of producing structural foam articles comprising:

(a) preparing a melt of at least one thermoplastic having about 2% to about 15% by volume reinforcing particles having one or more layers of 0.7nm-1.2 nm thick platelets, wherein more than about 50% of the reinforcing particles are less than about 20 layers thick, wherein more than about 99% of the reinforcing particles are less than about 30 layers thick, and said melt comprising at least one blowing agent present in a range from about 0.5% to about 10% by weight; and

(b) subjecting the polymer melt to a molding process, wherein the molding process is a process selected from the group consisting of injection molding and extrusion molding.

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 99/29990

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29C67/00 C08K3/34 B29C44/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C C08K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 739 007 A (OKADA AKANE ET AL) 19 April 1988 (1988-04-19) column 2, line 50 -column 3, line 65	1,2
Y	US 5 717 000 A (SUH KYUNG W ET AL) 10 February 1998 (1998-02-10) abstract column 1, line 1 -column 4, line 26	1,2
P,X	WO 99 61287 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2
P,X	WO 99 61281 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 May 2000	15/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Philpott, G

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 99/29990

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 99 61237 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2
P,X	WO 99 61236 A (MAGNA INTERNATIONAL OF AMERICA ;WILSON PHILLIP S (US)) 2 December 1999 (1999-12-02) the whole document	1,2
A	EP 0 747 323 A (AMCOL INTERNATIONAL) 11 December 1996 (1996-12-11) the whole document	1,2
A	US 5 001 005 A (BLANPIED ROBERT H) 19 March 1991 (1991-03-19) column 2, line 50 -column 3, line 30	1
A	US 5 747 560 A (MAXFIELD MACRAE ET AL) 5 May 1998 (1998-05-05) the whole document	1,2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter ...nal Application No
PCT/US 99/29990

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4739007 A	19-04-1988	JP 62252425 A	04-11-1987
		JP 8022946 B	06-03-1996
		JP 62074957 A	06-04-1987
		DE 3632865 A	02-04-1987
US 5717000 A	10-02-1998	AU 712100 B	28-10-1999
		AU 2132297 A	10-09-1997
		BR 9707867 A	27-07-1999
		CA 2247194 A	28-08-1997
		CN 1212001 A	24-03-1999
		CZ 9802639 A	13-01-1999
		EP 0882089 A	09-12-1998
		NO 983856 A	21-08-1998
		PL 328459 A	01-02-1999
		WO 9731053 A	28-08-1997
WO 9961287 A	02-12-1999	NONE	
WO 9961281 A	02-12-1999	AU 4007499 A	13-12-1999
WO 9961237 A	02-12-1999	AU 4005799 A	13-12-1999
WO 9961236 A	02-12-1999	AU 4089099 A	13-12-1999
EP 0747323 A	11-12-1996	US 5578672 A	26-11-1996
		CA 2178398 A	08-12-1996
		JP 9020514 A	21-01-1997
		US 5721306 A	24-02-1998
		US 5837763 A	17-11-1998
		US 5760121 A	02-06-1998
		US 5844032 A	01-12-1998
		US 5849830 A	15-12-1998
		US 5877248 A	02-03-1999
US 5001005 A	19-03-1991	US 5112678 A	12-05-1992
		US 5102728 A	07-04-1992
US 5747560 A	05-05-1998	AT 159270 T	15-11-1997
		CA 2115255 A	04-03-1993
		DE 69222773 D	20-11-1997
		DE 69222773 T	12-02-1998
		EP 0598836 A	01-06-1994
		JP 2674720 B	12-11-1997
		JP 6504810 T	02-06-1994
		WO 9304117 A	04-03-1993
		WO 9304118 A	04-03-1993